Module 2: Advanced Microcontrollers & Smart Systems

12-Class Detailed Syllabus • Robotics Education Platform

Target Audience: High School Students (Classes 11–12) / College Freshmen
Duration: 12 Classes (1 Hour Each)

Class #	Topic & Components	What You Will Build & Learn
Class 1	**32-Bit Microcontroller Architectures: ESP32 & STM32**• ESP32 Dual-Core & STM32 ARM Cortex-M3 (Blue Pill)• 3.3V Logic & ST-Link V2	Compare 8-bit vs 32-bit MCUs, set up board packages, handle 3.3V power rails, and flash firmware via ST-Link and USB.
Class 2	**Wireless Connectivity: ESP32 Wi-Fi & Bluetooth**• ESP32 Wi-Fi (AP & STA Modes) + Bluetooth Low Energy (BLE)• HTML/Web Servers	Provision ESP32 to connect to local Wi-Fi, host a local interactive HTML web server, and trigger board outputs wirelessly.
Class 3	**High-Precision Actuation: Stepper Motors & Drivers**• Bipolar Stepper Motors & A4988 / ULN2003 Drivers• Microstepping Controls	Drive stepper motors with high precision, configure microstepping resolution, and control exact step angles for mechanical positioning.
Class 4	**Motion Telemetry: IMU Sensors & Inertial Measurement**• MPU6050 6-Axis Motion Sensor (Accel + Gyro)• I2C Protocol & Angle Filtering	Read 6-axis motion data over I2C bus, compute real-time pitch/roll angles, and filter sensor noise for motion tracking.
Class 5	**Advanced Displays & Communication Busses**• SSD1306 0.96" OLED Displays• SPI & I2C Data Protocols	Compare SPI vs I2C bus speeds, interface high-resolution OLED displays, and render real-time telemetry plots and custom graphics.
Class 6	**Project 1: ESP32 IoT Weather Station & Web Dashboard**• ESP32 + BME280 Atmospheric Sensor + OLED Display• REST Web Server	**Hands-On Build:** Build a wireless environmental monitor that displays live temperature, humidity, and barometric pressure

Class #	Topic & Components	What You Will Build & Learn
		on an OLED screen and streams data to a web browser dashboard.
Class 7	**Project 2: Wireless Wi-Fi / Bluetooth Controlled Rover**• ESP32 + L298N Motor Driver + 2WD Chassis• Web App Joystick UI	**Hands-On Build:** Build a high-speed wireless rover controlled via a custom web app interface or mobile Bluetooth app with safety timeout protocols.
Class 8	**Real-Time Operating Logic: Hardware Interrupts & Timers**• ESP32/STM32 Hardware Interrupts (ISR) & Timer Counters• Non-Blocking Code	Replace laggy delay functions with hardware interrupts and timer interrupts for high-speed, non-blocking execution.
Class 9	**Introduction to Single-Board Computers: Raspberry Pi**• Raspberry Pi 4/5, Raspberry Pi OS, Linux Terminal• GPIO Hardware Pins & Python	Set up Raspberry Pi OS, navigate Linux terminal commands, access GPIO pins, and run Python scripts for hardware control.
Class 10	**Computer Vision & Camera Integration on Raspberry Pi**• Raspberry Pi Camera Module / USB Webcam• OpenCV & Image Processing	Interface Pi Camera, capture real-time video streams, and apply OpenCV filtering for color detection and motion tracking.
Class 11	**Project 3: Raspberry Pi AI Vision Smart Security System**• Raspberry Pi + Pi Camera + PIR Motion Sensor + Buzzer/OLED• OpenCV Face/Motion Detection	**Hands-On Build:** Build a smart security system that detects motion, captures intruder photos using OpenCV, logs security alerts, and activates audio/visual warnings.
Class 12	**Project 4: Self-Balancing / IMU Feedback System & Graduation**• MPU6050 + Motor Driver + Closed-Loop Control Systems• System Optimization	**Hands-On Build:** Integrate MPU6050 motion feedback with motor actuation to create a closed-loop dynamic balancing system, showcase projects, and receive certificates!